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HENRY

**A REGIONAL SIMULATION SYSTEM
FOR DEMOGRAPHIC-ECONOMIC MODELING**

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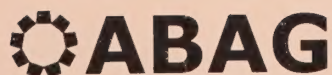
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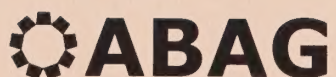


Association of Bay Area Governments

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HENRY

A REGIONAL SIMULATION SYSTEM FOR DEMOGRAPHIC-ECONOMIC MODELING

I. OVERVIEW

The HENRY model is an analysis and simulation tool that assists in regional planning and forecasting for the San Francisco Bay Area. It serves the dual purposes of allowing us to explicitly describe the assumed values and relationships that drive our economic modeling, and to use those relationships to create forecasts and scenarios.

The primary objectives of the system are:

1. To describe the relationships between population, employment, labor force requirements, income, economic activity, and energy requirements at a regional level.
2. To allow changing population characteristics such as changes in births, deaths and migration.
3. To analyze the effects of employment on migration within the context of an area's population.
4. To understand the assumptions that are made about economic development and the manner in which those assumptions influence the region.
5. To evaluate external forces (e.g., at the national level) acting upon a region in terms of economics and demographic variables (e.g., the demand for a region's exports).
6. To assess the impacts of interest rates and energy prices on production and investment in a regional context.

The HENRY model updates a previous ABAG regional planning model known as RIS. That model was originally developed in the early 1980s. It was written in FORTRAN IV and operated on an IBM 4341 at the University of California, Berkeley. By the early 1990s, the RIS model migrated to the PC platform where it operated in batch mode in MS FORTRAN.

In contrast, the HENRY model is written using Visual Basic for Applications (VBA) imbedded in an Excel workbook. The various sheets in the workbook contain input data, areas to adjust assumptions and

model equations. Once the model is run, additional worksheets are generated to show scenario results.

Model Components

HENRY is an interactive forecasting model that permits the user to change a variety of variables on an annual basis. This design flexibility permits the user to test changes to conditions, such as on the growth of capital investment in the region and ultimately employment growth. The system contains 5 sub-components that are used to produce the economic and demographic requirements of the region.

The first component of the model is the input data. The input data has two subsets contained in separate spreadsheets. The first subset is base year data and is contained in the spreadsheet "Input Data." The second subset is the next year in the progression and is contained in the spreadsheet "Base Year."

As a semi-dynamic model, HENRY needs two consecutive years of data to begin the forecasting process. The model uses the existing level of variables as an input to the forecasting process. In other cases, it needs to identify a recent rate of change in the variable.

Components two (Economics) and three (Demographics) are the analytical sub-routines used in the forecast of economic and demographic conditions for the region. The Demographics modeling is contained in a single spreadsheet of the workbook. Demographic estimates are made using a cohort survival model that is specific to each of the nine counties in the region. The Economics Component is made up of the Economic Calc spreadsheet and a separate spreadsheet (IO) that contains the direct requirements coefficients from our regional input-output modeling. The I/O is designed to produce outputs of thirty-five industry sectors that best reflect the dynamics of the regional economy. These industries are currently defined by SIC Codes, but will soon be changed to the NAICS system. The two sub-components perform the calculations for subsequent forecast years.

The fourth component in the modeling process contains assumption changes and is contained in two spreadsheets called "Economic Changes" and "Demographic Changes." These grouping allow us to represent long-term trends that we are trying to model in a cohesive way and provide a central location for the model to access those assumptions.

The fifth component of the model is the VBA programming. While it is not initially evident from looking at the workbook, this component provides the mechanics to take the model and grow the economy over multiple years.

The design of the HENRY model is to take the input-output coefficient table originally estimated for the region and update certain components as a way of overcoming some of the restrictive assumptions inherent in the input-output conception of an economy. Changes in productivity are used to update the employment multipliers. Estimates of manufacturing capacity can be used to restrict the regional share of output. Once those adjustments are made, the demand for final goods and services drives the amount of production by the Bay Area economy. Additionally, the level of demand for final products is endogenously determined as the model estimates price changes for goods, local personal consumption expenditures, population, and government transfer payments.

The advantage of a semi-dynamic forecasting system such as HENRY is that it incorporates negative and positive feedback with respect to changing economic and demographic conditions. Linking and identifying feedback increases our understanding of the impacts of policies or events on the development of the region. For example, in the economic model a series of equations are used to calculate annual change in the growth of output per worker. As the growth rate in output per worker falls, the number of workers needed to produce a defined output rises. This is interpreted as a positive feedback, since increasing employment is socially beneficial. On the other hand, falling output per worker rates are translated into higher production costs, which affect the demand for exports and personal consumption expenditures in the region. This is translated as a negative feedback because rising production costs affect demand for output in the model. In addition to affecting demand, the model translates changes in the rate of growth in output per worker into changes in the demand for capital investment in each industry. That is, the probability of increasing the proportion of capital investment for replacement and expansion of the capital plant rises with falling rates of growth of output per worker. Implicit in this concept is capital-labor substitution.

Finally, we recognize that understanding the behavior of a system (such as a social system) through feedback is equally important in model building as obtaining a result that replicates historical events. Since replicating an event may not improve our understanding of the mechanisms that interact to create the event, as our forecasting of

future events would not be aided by the simple replication of known historical facts.

Therefore, the HENRY model is presented as an applied research tool designed to increase our understanding of the planning needs of a decentralized economy.

HENRY: A Semi-Dynamic Regional Model

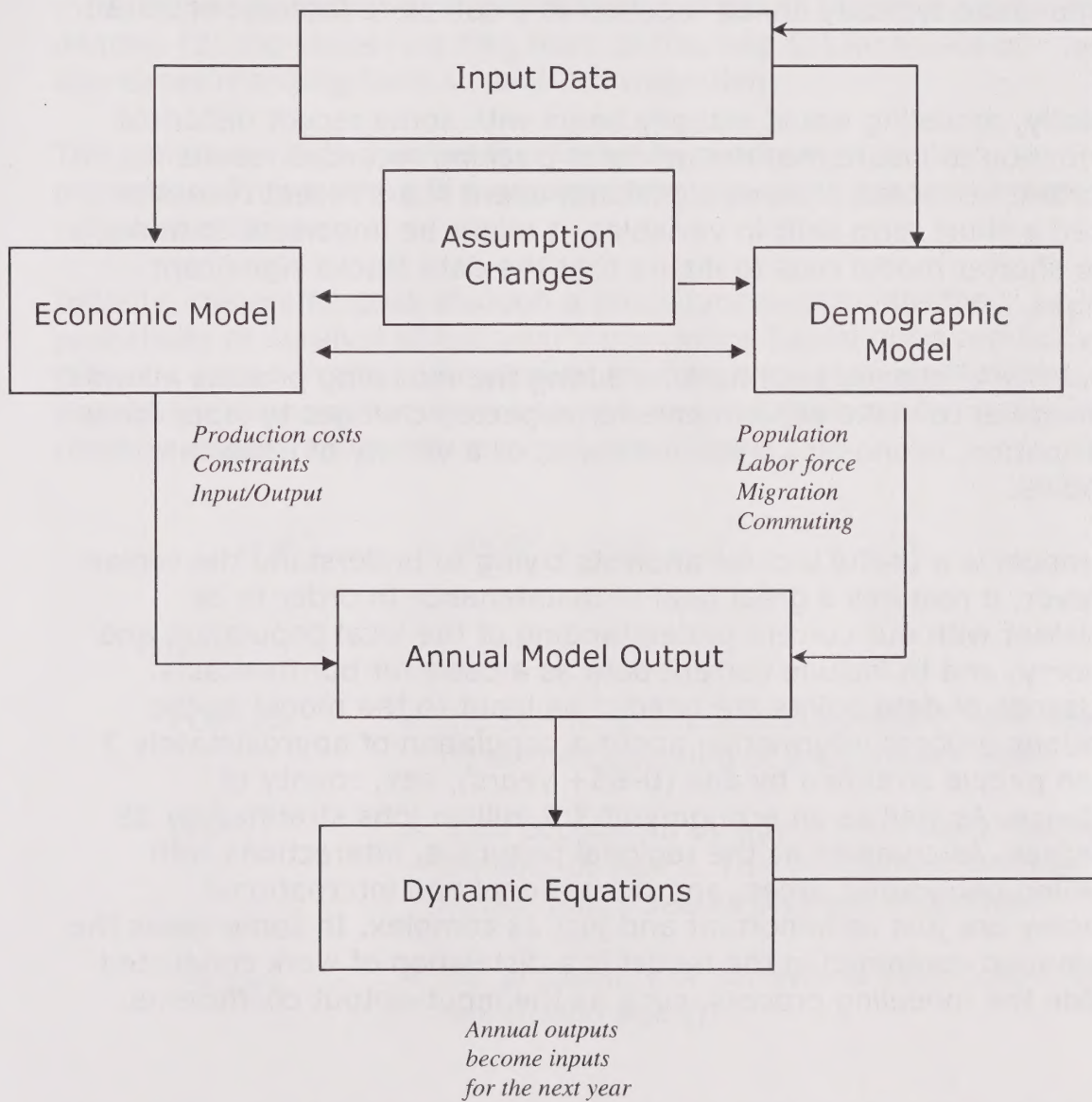
The interrelationships of the five sub components to the model are outlined in Figure 1. It is useful to think of the model growing the population and economy year by year. The initial data and any updated model assumptions provide the basis for calculating the first year of the forecast. The equations contained in the economic and demographic components of the model can take this information and produce annual model output for a single year as outlined in the illustration.

Note that the economic and demographic components interact as they jointly calculate certain output values. For example, the economic equations will use information on available labor force to calculate unemployment rates. The demographic equations will use labor demand as a factor in calculating migration and inter-regional commuting. Components of the two models decompose the regional totals into county level data in most cases.

The annual model output is a complete yearly data set, comparable to one of the annual data sets that make up the input data for the model. As a result, it can be combined with part of the existing input data to make a new input data set, which can be used to calculate the results for the next year in type. The Dynamic Equations in the model automate the process of taking the annual model results and transforming them into input that can be used to calculate a subsequent year.

For example, if the initial input years for the model are 1999 and 2000, the economic and demographic components of the model will take that information along with any changes to assumptions and produce a new annual output for 2001. The dynamic equations will take that annual output data, save the result, and change the input data so that the model inputs become data for 2000 and the just

Figure 1
Henry Model



calculated 2001. This provides the economic and demographic sub-components with the data it needs to calculate annual output for 2002. This process can go on for any number of years, but the model generally looks at a series of up to five-year iterations. These iterations are typically linked together in a complete forecast of 20-30 years.

Typically, modeling would actually begin with some recent historical information to insure that the model is tracking recorded results for important variables. If some significant event like a recent recession caused a short term shift in variables, it might be important to make some shorter model runs to insure that the data tracks significant changes.

The ability to change assumptions during the modeling process allows the modeler to make adjustments for expected changes to labor force participation, economic competitiveness, or a variety of important variables.

The model is a useful tool for analysts trying to understand the region. However, it requires a great deal of maintenance in order to be consistent with our current understanding of the local population and economy, and to include current data as a basis for our forecasts. Thousands of data points are needed as input to the model as the equations process information about a population of approximately 7 million people stratified by age (0-85+ years), sex, county of residence. As well as an economy of 3.5 million jobs stratified by 35 industries. As complex as the regional picture is, interactions with adjoining geographic areas, and the national and international economy are just as important and just as complex. In some cases the information contained in the model is a distillation of work conducted outside the modeling process, such as the input-output coefficients.

II. THEORY AND STRUCTURE OF POPULATION MIGRATION AND LABOR FORCE MODELS

The San Francisco Bay Region consists of nine counties that border the San Francisco Bay. The study region is designed as a single, functional unit which includes all of the daily economic and social activities of the population and industries within it.

The Demographic Model

The population projections sub-model is broken into groups based on age and sex, called cohorts. The age-sex cohorts are subject to the three major components of population change: (1) decreases due to deaths, (2) increases resulting from births, and (3) increases or decreases resulting from in- and out-migration.

The cohort-survival method is selected to produce population projection. This method is a proven technique with reasonable data requirements.

Initially, the model goes through a procedure to calculate the probability of survival of last year's population based upon mortality rates by cohort in the same population. The base year resident population expected to survive to year $t+1$ is calculated by multiplying resident population by the survival rate. That is,

$$POP_{j,t+1}^i = (POP_{j,t}^i)(SR_{j,t+1}^i) \quad (1)$$

Where:

$POP_{j,t+1}^i$ = the surviving population by age (j) and sex (i) at the beginning of the forecast year.

$POP_{j,t}^i$ = total population by age (j) and sex (i) as of the end of year t. This population includes births minus deaths plus net migration.

$SR_{j,t+1}^i$ = the probability of survival of each cohort by sex (i) and age (j).

Since survival rates are calculated at the beginning of each forecast year and are derived from mortality rates, the system user may alter the survival rates by using the change routine. The difference between the surviving population and the initial population for the forecast year is deaths. This is expressed as:

$$DEATH_{j,t+1}^i = POP_{j,t}^i - POP_{j,t+1}^i \quad (2)$$

The surviving population is used to calculate the births for the forecast year. There are three indicators that form the basis for computation of age specific fertility rates. These are: the completed fertility rate, births by the age of mothers, and the timing pattern. Of these, the completed fertility rate is most often used as the singular descriptive statistic of fertility patterns. In this model, the period fertility rate rather than the completed fertility rate is used. Period fertility implies the average fertility behavior of all the fertile cohorts at a point in time. Hence, the rate combines a single year picture of each cohort's habits to form an indicator of the current birth rate. The period fertility rate is subject to fluctuation, based on variation in short-term social and economic trends. Less and slower variation is attributed to the completed fertility rate as it deals with generations of women and their whole childbearing cycle. Now, total births are calculated as follows:

$$\text{Total Births}_{t+1} = (\text{FERTLY}) (\text{BR}^i_{t+1}) (\text{POP}^i_{t+1}) \quad (3)$$

Where:

Total Births = the total number of children born to a female cohort between the ages of 14-44 in the forecast year

FERTLY = the period fertility rate. The average number of births per female cohort in the forecast year

BR^i_{t+1} = the timing pattern of births by female cohort in the forecast year

POP^i_{t+1} = the female population in the forecast year

Statistically, approximately 51.5% of all births are male. Total births are multiplied by the above figure to determine male births which are then added to the surviving male population. The difference between total births and male births are female births, and those are added to the surviving female population. Recalculations of deaths are undertaken at this stage to estimate the surviving children that will be added to the forecast year population.

Migration Model

The migration component of the HENRY model focuses on the macroeconomic factors that pull people toward the region, or push them away. While the data used to examine this question is net-migration data and therefore includes both in and out migration, the model concentrates on the economic factors that attract an overall number of in-migrants. Although we have performed some empirical tests on regional cost of living factors that might be associated with out migration or a reduced flow of new migrants to the region.

Explanatory models of interregional migration note that employment opportunities, amenities and the demographic characteristics of an area are the underlying reasons that people or households choose to migrate. Given the relative stability of amenities and demographic characteristics of the Bay Area, our modeling of migration behavior focuses on economic factors.

The economic success of the region is represented in the model by decreasing unemployment rates and increasing rates of income growth. The unemployment rate in this case shows the

$$\text{ECONMIGRATION} = a * \text{EMPLOYOPP}_{t-1} - b * \text{CPIDIFF} \quad (4)$$

Where:

EMPLOYOPP_{t-1} = Unemployment rate in the Bay Area compared to a reference unemployment rate.

CPIDIFF = historical differences in the cost of living in the Bay Area compared to the U.S. generally

a, b = statistically estimated coefficients.

Economic migrants are attracted by employment opportunity both short and long term. Bay Area Unemployment rates at a relatively low level indicate immediate employment opportunities that will attract migrants in the next year.

Differences in the cost of living between the Bay Area and the rest of the U.S. limit the amount of migration that can occur as potential

migrants must conclude that even with employment opportunities their economic well being is not enhanced by relocating.

Certainly, it is also the case that some people will choose to relocate to the region in order to retire, but that behavior is relatively stable. Given the cost of living in the region, the Bay Area is not perceived to be particularly attractive to external migrants, and there is some out migration to access real estate equity. Retirement migration is represented as a slow growing trend based on historical data and is represented most specifically when net migrants are assigned to age cohorts.

Retirement migrants are modeled as a portion of the cohort age 65 and greater. A historical series on retirement migrants who would migrate to the region is calculated. The change in over 65 migrants is a function of the change in real growth in personal income. That is,

$$OLD3 = [(.015884)(MU) - (.0089)(ALPHA)] * POP66 \quad (5)$$

Where:

OLD3 = the over 65 migrants who migrate to the region

MU = 1.0, IF (PIPCH $\geq$ 0.02) ELSE

MU = PIPCH + 1.0

ALPHA = 1.0, IF (PIPCH $\leq$ 0.02) ELSE

ALPHA = PIPCH + 1.0

POP66 = the population in year t over 65 years old

The coefficients in Equation (5) are set for the San Francisco Bay Region. If the model is applied to other regions, estimates of the importance of retirement migration to the total migration should be undertaken.

Migrants are summed over all of the class of migrants to obtain the net migration for the forecast year. That is,

$$MIGRATION = ECONMIGRANT + RETIREMIGRANT \quad (6)$$

Where:

MIGRATION = Net migration in forecast year

ECONMIGRANT = Net economic migration

RETIREMIGRANT = Net migration for retirement

The migration sum is distributed over age groups based upon a percentage distribution of the age of migrants from historical migration estimates. This distribution is added to the forecast year surviving population to obtain the age cohort population in the forecast year.

Labor Force Participation Forecast

Now that the total population by age cohort has been estimated, labor force participation is forecast. The first step in this process is to forecast labor force participation rates for the year. Labor force participation rates (LFPR) are a function of:

- a) changes in the growth of jobs
- b) changes in real income growth
- c) exogenous change by the user

LFPR for men is expressed as:

$$LFPR_{j,t+1}^i = LFPR_{j,t}^i (ZZ (\exp^{GQ})) \quad (7)$$

Where:

$LFPR_{j,t+1}^i$ = forecast year labor force participation rates for men by age (j).

$LFPR_{j,t}^i$ = last year's labor force participation rates for men by age (i).

$$ZZ = [(E32/OLDE32 + E31/OLDE31)/2.0] * (1/QB) \quad (8)$$

Where:

$QB = PIPCH_{t+1} / PIPCH_t$ (IF $PIPCH_{t+1} / PIPCH_t < 1.0$, ELSE

$QB = 1.0$

$E32 =$ total employment in forecast year

$OLDE32 =$ total employment in the last forecast year

$E31 =$ total jobs in forecast year

$OLDE31 =$ total jobs in the last forecast year

$GQ =$ a constant which varies over time.

GQ is used to reduce the growth in labor force participation of men relative to the increase in labor force participation of women. This constant varies from region to region.

LFPR for women is expressed as:

$$LFPR_{j,t+1}^i = LFPR_{j,t}^i (ZZ (\exp^{GG})) \quad (9)$$

Where:

$LFPR_{j,t+1}^i =$ forecast year labor force participation rates for women by age (i).

$LFPR_{j,t}^i =$ labor force participation rates for women last year

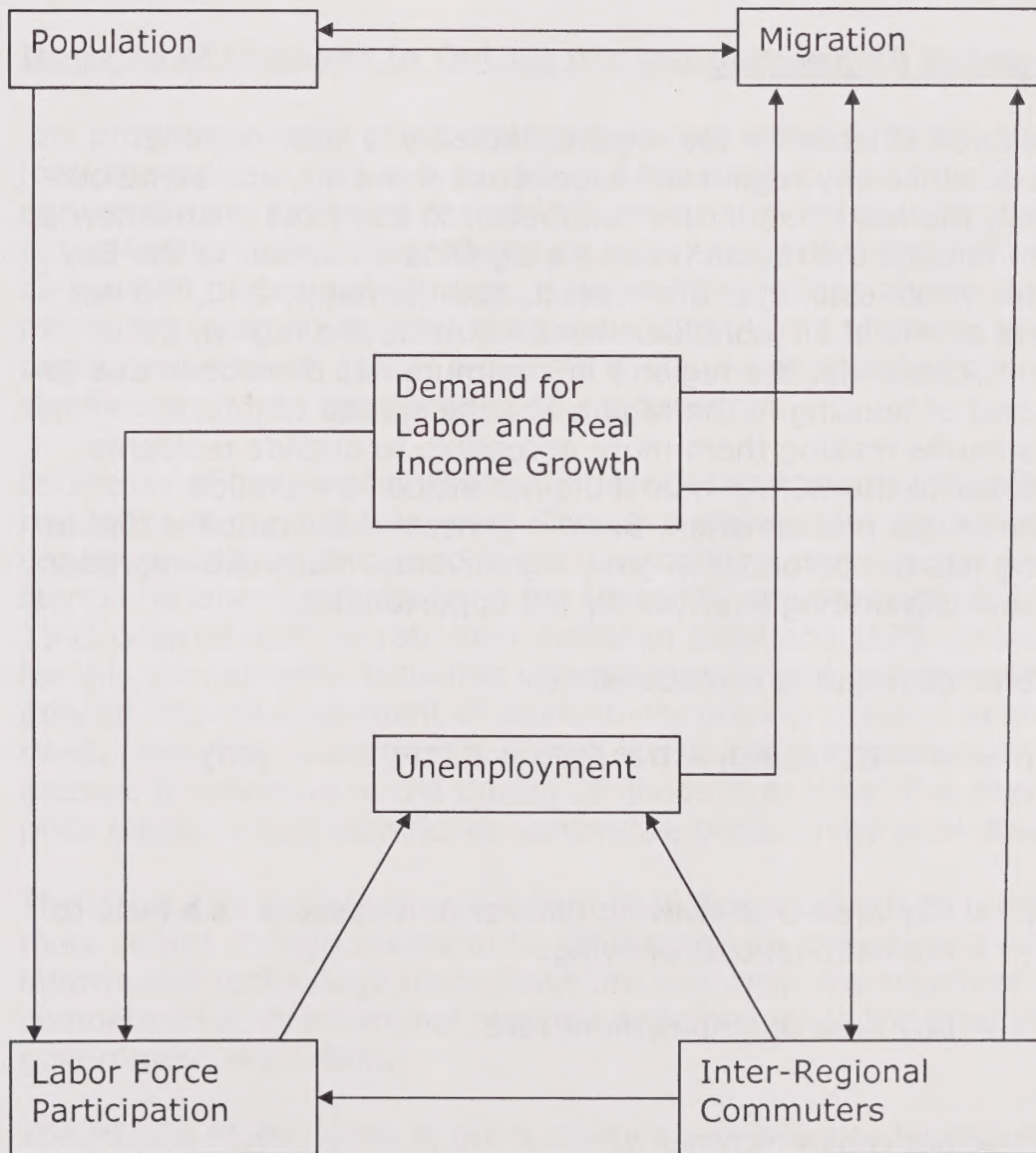
$ZZ =$ same as in Equation (8)

$GG =$ a constant which varies over time.

GG expresses the relative growth in the participation of women to men in the labor force, and varies from region to region.

Finally, LFPR are lagged by one year. That is, the labor force participation rates for the forecast year are applied to next year's

Figure 2
Interaction of Demographic and Labor Force Models



population to obtain the labor force in that year. This lag is applied because it represents a population's response to changes in economic activity this year. Thus, an estimate of labor force participation for the forecast year is obtained by multiplying this year's population by last year's (end of the year) LFPR.

Inter-regional Commuting

Another source of labor for the region's industry is inter-regional commuters. While any region will experience some in-, and some out-commuting, the net effect in the San Francisco Bay Area is an inflow of labor from outside the region holding a significant number of the Bay Area's jobs. While estimates are inexact, approximately 140,000 net commuters or 4% of all jobholders reside outside the region. Other research indicates that the region's in-commute has developed due to the high cost of housing in the region and the spread of jobs to outlying suburbs making them more accessible to outside residents. The precursor to the HENRY model did not include an explicit description of this phenomenon. But the general expectation is that in commuting has the potential to grow significantly. Much like migration, interregional commuting is driven by job opportunities.

Interregional commuting is modeled as:

$$\text{INCOM}_{t+1} = A + B1 \cdot \text{BCAD}_t + B2 \cdot \text{BUR}_t + B3 \cdot \text{PCI}_t \quad (10)$$

Where:

BCAD_t = Bay Area cost of living difference measured as a ratio to the national cost of living.

BUR_t = Bay Area unemployment rate

PCI_t = per capita income

All values are lagged in order to allow the previous year's data to be used as an estimate of net in commuting.

III. THEORY AND STRUCTURE OF ECONOMIC SUBMODEL

A primary objective in designing the model is to create a feedback system with respect to the economy, which reasonably approximates the behavior of economic units in a regional context.

Impacts of Changes in Output per Worker Growth Rates

The program initially sets output per worker in line with the results from the input-output results. Initial annual rates of change in output per worker are set using recent U.S. data on an industry by industry basis. Recognizing that productivity is an essential component of costs and capital - labor substitution, a series of equations are designed to model the interactions between productivity, costs, demand and capital investment. This is a portion of the model that has changed significantly when compared to its predecessor.

Estimates of historical productivity growth have been substantially revised over the last few years. The pace and pattern of productivity growth is actively discussed in the economics profession. By some standards labor productivity in the United States between 1973 and 1995 grew at half the rate seen between 1959 and 1973. Explanations for this phenomenon including oil price shocks and government budget deficits. Mis-measurement of productivity growth has also been widely cited, given the governments recent revision of price indices to account for changes in the quality of goods over time. The change to price indices would significant narrow the productivity slow down.

The latter 1990s have seen a return to higher productivity levels. This more recent change seems to be attributable to the growing use of information technology throughout the economy, the response to competition in international markets and changes in the level of government regulation.

The HENRY Model looks at productivity on an industry by industry basis. Changes in the productivity of labor are used to revise the employment multipliers for each industry originally estimated for the input-output model. In each new forecast year the model estimates the amount of gross output required from each industry, and in turn, the amount of employment required to generate that gross output.

The HENRY model makes the conventional assumption that labor productivity is increasing at a decreasing rate. Recent historical

experience has certainly changed many analysts perception of our economy's structure. However, technological growth and a workforce that is particularly well educated argue for the assumption embedded in this model.

Initially, a function (F) is calculated for each forecast. That is,

$$G = \text{ALPH1} \quad (11)$$

Where:

$$\text{ALPH1} = \text{ALPH} * F$$

$$F = 1/(t-T)^{(a2*LABORPROD)}$$

$$\text{ALPH} = (\text{PERSINCOME}_{k,t+1} - \text{PERSINCOME}_{k,t})/\text{PERSINCOME}_{k,t}$$

The function (F) is used to change the growth in the rate of change for the output per worker in each of (k) industries. Implicit in the variable (ALPH1) is the concept that real growth in personal income indicates that productivity would not be falling at the same rate as if real income were not growing. It tends to reduce the impact of GA, which may result in an increase in the rate of growth in output per worker depending on the period of time. During the late 1970's and early 1980's, a marked decline on productivity growth occurred. Although a clear cause and effect relationship has not been drawn between inflation, costs and capital investment, we know that real income has grown only slightly between 1977-1981 on a per capita basis, and in some regions of the country has actually fallen when computed on a real income per worker basis. Hence, a link is drawn between real income change and changes in the rate of growth in output per worker.

Next, the impact of real interest rates is applied to the weighted annual change in output per worker rate (GH). Interest reduces the annual growth of output per worker rate. The underlying theory is that high real interest rates affect the capability of industry to replace capital plant and equipment as well as to expand existing plant. If replacement or expansion is affected, the aging of existing plant increases which impacts productivity growth. Therefore,

$$xy = \frac{1}{(\text{RINT})^{.005}} \quad (12)$$

Where:

xy = the impact of interest rates on productivity growth

$RINT$ = real interest rate, the transaction cost of doing business

Now, equation (12) becomes

$$GH = GH * xy.$$

Next, (GH) is multiplied by base year output per worker rate to obtain the output per worker rate for the forecast year. That is,

$$OTPWS_k = OTPWR_k * GH \quad (13)$$

Where:

$OTPWS_k$ = forecast year output per worker rate

$OTPWR_k$ = base year output per worker rate

GH is a factor which is applied to base year output per worker rate to identify change

Finally, $Q_k = OTPWR_k - OTPWS_k \quad (14)$

Where:

Q_k = change between forecast year and base year

Now, the variable Q is used as a surrogate for those costs associated with changing rates of growth in productivity. Deficiencies in translating changes between the forecast year and the base year output per worker rate focus on two concepts. First, the program literally assumes that the difference between the forecast year and base year represents a price change in producer goods associated with changes in productivity. Implicit in this concept are factors such as wage bills and hours workers. This value attempts to approximate the linkage between productivity and producer prices. Therefore, the exact relationship may not be correctly interpreted with respect to the actual price effects. On the other hand, if a forecast year output per worker rate growth is lower than last year's rate, implicitly it is suggested that

physical production per hour worker may not be growing at the same rate as in the past. Therefore, the proportion of the wage bill as a percentage of total production value might rise resulting in increases in production costs associated with wage bills. This is translated into producer prices. Another methodological difficulty is that elasticities applied to Q represent price elasticities at the consumer level. Although producer prices translate ultimately into consumer prices, they do not represent the middleman's response to input prices with respect to (a) other substitution or (b) orders. Therefore, the user should be aware of these deficiencies at this time in the economic component of HENRY.

After Q is calculated it is multiplied by price elasticities to obtain theoretical price impacts of changes in output per worker rates on regional consumption by consumers, exports to the rest of the nation, and ultimately on the growth in gross output. That is,

$$FW_k = Q_k * ELASP_k \quad (15)$$

Where:

FW_k = price impact of productivity change for industry k.

$ELASP_k$ = price elasticities of industry k

Energy Price Impacts on Demand

For the purposes of calculating the impacts of energy price changes on producer prices and (ultimately on demand for goods and services and on changes in economic incentives to replace capital plant and equipment), the individual energy price effects are summed and averaged to represent a single price impact.

Hence,

$$PA = (P(1) + P(2))/2.0 \quad (16)$$

In this model about one-third of overall inflation initially is associated with changes in fuel costs. This overall impact will vary by region and depending upon the base period of the model. However, since prices are in current dollars, the real impact of fuel costs decline over time given constant price levels. This assumes that as real income rises, consumers adjust to current energy prices that remain stable over

time. For example, assume an annual increase in current dollars of 10 percent over a five-year period for the cost of fuel. Now the first year of the energy cost, a 10 percent increase in energy results in approximately a 3 percent contribution to overall price inflation. That is:

$$\begin{aligned} PE &= .33 \exp^{(-.33(t-2000))} \\ &= .33 \end{aligned} \quad (17)$$

PE is the energy price rise in constant dollars, and therefore reflects the price contribution of energy to overall inflation.

$$(.33)(.10) = .033$$

Hence, a 10 percent price increase initially translates into a 3.3 percent contribution to the overall inflation rate. In the fifth year of the forecast with a 10 percent annual increase in fuel costs, the overall contribution to inflation is:

$$PE = .33 \exp^{(-.33(5))}$$

$$PE = .0634$$

Hence, 10 percent multiplied by (PE) translates into a 1 percent overall contribution to the inflation rate. If the inflation rate was 10 percent in the base year, 3.3 percent of the rate was derived from fuel costs rises. If the rate were still 10 percent in the fifth year, fuel costs would contributed to only 1 percent of the overall 10 percent rate.

This price level is next multiplied by price elasticities to obtain the impacts on individual industries with respect to production costs, that is,

$$FE_k = X(PE)(ELASP_k) \quad (18)$$

Where:

FE_k = the cost impact of energy prices

X = coefficient for energy price impact on general costs

PE = energy price

ELASP_k = price elasticities

This variable (FE) is summed in the next section and in later parts of the algorithm to impact on consumer spending, exports and capital investment.

Price Impacts And Personal Consumption Expenditures

Initially, a price impact deflator is applied to general price increases for specific industry sector goods. Price associated with consumer expenditures is an input variable that the user may change on an annual basis. If the price increase is the same over a forecast period, the rule followed in the energy sector is applied here with respect to real price impacts. That is, if the price change from year to t to $t + n$ is the same, then:

$$\text{PRICCH}_{k,t+1} = \text{PRICCH}_{k,t} * \exp^{-05(t+n-t)} \quad (19)$$

Where:

$\text{PRICCH}_{k,t+1}$ = price level if no change in price from year t

$\text{PRICCH}_{k,t}$ = last year's price level from industry k

The effects of energy costs, productivity changes and general consumer prices are summed to reflect a total price impact on regional personal consumption expenditures, that is,

$$\text{FX}_k = \text{FW}_k + \text{FE}_k + \text{Q}_k \quad (20)$$

Where:

FX_k = total price impact for industry k

FW_k = productivity decline price impact

FE_k = energy cost impact

Q_k = consumer price impact

Personal Consumption Expenditure

Prices are applied to personal consumption expenditure (PCE) to obtain the price impact on PCE in the forecast year. Since PCE has both positive influences (growth in personal income and households) as well as negative influence (price increases), the equation used to calculate PCE in the forecast year is:

$$PCE_{k,t+1} = (PCE_{k,t}) \exp^{(.4(POPCH) + (ELASPK)(PIPCH)(.85) - Fx_{k,t+1})} \quad (21)$$

Where:

$PCE_{k,t+1}$ = forecast year PCE for goods from industry k

$PCE_{k,t}$ = current year PCE for goods from industry k

POPCH = total population change from year t to t+1

$ELASPK$ = real income elasticities of demand

$Fx_{k,t+1}$ = total price impact for industry k

Note that the coefficients apply are specific to the forecast region and require adjustment when the model is applied to other areas.

Because the variable (Fx_k) contains the impacts of price increases associated with consumers, the first step in calculating the price impacts associated with productivity changes and energy costs is to recalculate (Fx_k) in the forecast and exclude (Q_i) from the sum. Eventually, the adjusted (Fx_k) is applied to growth in export sales and capital investment in manufacturing for the forecast year that is,

$$Fx_k = Fw_k + Fe_k \quad (22)$$

Government Purchases, Exports

The model at this juncture calculates the expected government purchases in the forecast year. Government purchases are primarily limited to state and local government purchases necessary to maintain existing levels of operations. However, Federal government purchases that directly affect the local economies endogenously are included, such as postal services, military services and Federal civilian employment. The sub-routine permits exogenous changes to be

internalized. The user may apply a specific growth factor, which may be annualized or applied over several years. If the user does not input a variable, the model assumes that the base year input is to be applied to that forecast year. Government spending in this case does not include transfer payments that are adjusted and added to PCE. Government spending therefore is:

$$FD_{k,t+1} = FD_{k,t} (1 + \text{GROWTH}) \quad (23)$$

Where:

$FD_{k,t+1}$ = government purchases in industry k for year t+1

$FD_{k,t}$ = government purchases in industry k in year t

GROWTH = government revenue growth rate in forecast year

After government purchases by industry sector are calculated, estimates of the growth in U.S. Final Demand are made for the base year. Recall that demand in the National Economy (or International Economy) drives the growth in the exports from the region. After this year's growth in U.S. Final Demand is calculated, the model estimates the impacts of changes in productivity and energy costs on exports in this year, assuming competitive market conditions and or of product demand. Since energy costs are ubiquitous, higher costs will depress demand in general for the exports. The impact on exports are only felt for the forecast year, but the impact on the growth in exports is lagged one year to impact next year's exports. It is suggested in this procedure that the impacts of change in regional growth requires approximately one year to be felt at the national level. This is expressed as follows:

$$GNP_{k,t+1} = (1 + \text{GROW}_{k,t+1})(GNP_{k,t}) \quad (24)$$

Where:

$GNP_{k,t+1}$ = U.S. Final Demand for industry k in forecast year

$\text{GROW}_{k,t+1}$ = growth rate in industry k in the forecast year

$GNP_{k,t}$ = industry component of U.S. Final Demand in year t.

Next, we apply the cost impact directly to this year's exports.

$$\text{REGMKS}_{k,t+1} = \text{REGMKS}_{k,t} (1 + \text{RGMKSR}_{k,t-1})(\text{FX}_{k,t+1}) \quad (25)$$

Where:

$\text{REGMKS}_{k,t+1}$ = exports in forecast year

$\text{REGMKS}_{k,t}$ = exports in current year

$\text{RGMKSR}_{k,t-1}$ = rate of change in exports lagged one year

$\text{FX}_{k,t+1}$ = price effect on forecast year on exports

Finally, the impacts of regional cost changes are applied to the growth in export demand for the next year. This occurs with respect to both the growth in U.S. Final Demand (which represents absolute growth in the national market) and the growth in the share of the regions export potential. Note that the second equation in this series represents the potential exports in the forecast year, but the impacts of regional cost changes are not felt in the national demand until the next cycle. Therefore,

$$\text{RGMRSR}_{k,t+2} = (\text{RGMRSR}_{k,t+1})(\text{FX}_{k,t+1})^3 \quad (26)$$

$$\text{EXPORTS}_{k,t+1} = (\text{REMKS}_{k,t+1})(\text{GNP}_{k,t+1}) \quad (27)$$

$$\text{GROW}_{k,t+1} = (\text{GROW}_{k,t+1})(\text{FX}_{k,t+1})^2 \quad (28)$$

Capital Investment

The algorithm calculates this year's capital requirements and investments for each industry. Since investment decisions vary between industries, investment is divided into three independent components: investment in the construction sectors; investment in trade and finance, insurance and real estate; and investment required in manufacturing. Investments associated with agriculture, electric, gas and water utilities, services and government are aggregated and placed either in non-residential construction or utilities and highway construction.

The equations in the construction sector are rather simple. However, we feel that the equations present for a reasonable approximation of the significant variables associated with investment in the construction sectors.

Construction

Both new residential construction and maintenance and repair construction are a function of: the change in real personal income; change in total population, and real interest rates. The change component is expressed as

$$ACIa_{t+1} = \ln((1+PIPCH)(\sqrt{1+POPCH})) \quad (29)$$

Where:

$ACIa_{t+1}$ = change in all residential construction

$PIPCH$ = real growth in personal income

$POPCH$ = % change in population from year t to $t+1$

Non-residential construction is a function of the change in total jobs from year t to $t+1$, and is expressed as:

$$ACIb_{t+1} = \sqrt{1+((E-OLDE)/OLDE)} \quad (30)$$

Where:

$ACIb_{t+1}$ = change in non-residential construction for year $t + 1$

E = total forecast year jobs

$OLDE$ = total last year jobs

Construction activities associated with utilities and highways is a function of population change and government spending. It is expressed as

$$ACIc_{t+1} = \ln(.55(1+POPCH) + .45 \sqrt{(GPF/GPB)^{.60}}) \quad (31)$$

Where:

$ACIc_{t+1}$ = change in utilities and highway construction

GPF = forecast year government spending

GPB = base year government spending

Next, the real interest rate is applied to the change components in equations (29), (30), (31) to dampen construction activity.

The equations associated with the real interest rates are:

$$XINT = \text{COS} ((RINT) (17)) \quad (32)$$

$$AE = (1 / XINT)^2 \quad (33)$$

$$BE = (XINT)^2 \quad (34)$$

Where:

RINT = the transaction costs associated with borrowing money.

Finally, the change variables are applied to the stock of new construction that was in place last year to obtain the stock of new construction or maintenance and repair in the forecast year. That is,

$$CI_{t+1} = CI_t (\exp^{(ACI_{t+1} ECI_{t+1})}) \quad (35)$$

Where:

CI_{t+1} = new construction in constant dollars for year t+1

CI_t = new construction in constant dollars for year t

$ACI_{t+1} = ACIa_{t+1} + ACIb_{t+1} + ACIc_{t+1}$

$ECI_{t+1} = AE \text{ or } BE$

Mining and Manufacturing

Next, capital requirements associated with mining and all of the manufacturing sectors are calculated. Capital requirements in manufacturing are a function of the growth in real output, replacement of existing equipment, energy cost, and real interest rates. Capital output ratios are expected to change considerably over the long-run based upon the relative expensiveness and substitutability of labor, capital and new technology.

For each forecast year, a new ratio is calculated. This ratio is a function of the changes identified above. Hence,

$$r_{kt+1} = r_{kt}((1 + Rcr_{k,t+1})C^3 + FD_{k,t+1})e \quad (36)$$

Where:

$r_{k,t+1}$ = the new capital-output ratio rate of change

e = the effect of interest rates expressed

e = $\sin(BE)$, if the real interest rate is greater than 0.0

e = $\sin(AE)$, if the real interest rate is less than 0.0

r_{kt} = last year's capital-output ratio rate of change

C = $FW + 1$

C is used to increase the replacement rate of exist capital in order to reduce energy costs and increase the rate of change in output per worker.

$Rcr_{k,t+1}$ = change in capital replacement due to changes in output

$Rcr_{k,t+1}$ is expressed as:

$$Rcr_{k,t+1} = DRCRcr_{k,t+1} \quad (37)$$

Where:

$$DRCRcr_{k,t+1} = (1 - \cos(DOR_{k,t+1} * 10))DL_k$$

$$DOR_{k,t+1} = (OUTPUT_{k,t} - OUTPUT_{k,t-1}) / OUTPUT_{k,t-1} \quad (38)$$

$DL_k = 1 / \text{average life of capital equipment in sector } k$

The series of equations 36-38 represent the impacts of an increase in real output on the physical plant. This results in an increase in the rate of replacement of existing plant and equipment due to increased usage.

After the replacement impact has been calculated, the model estimates the capital requirement associated directly with increased demand and independent of replacement. That is,

$$FD_{k,t} = PCE_{k,t} + GO_{k,t} + EX_{k,t} + CI_{k,t} \quad (39)$$

Where:

PCE = personal consumption expenditures

GO = government purchases

EX = exports

CI = capital Investments

In addition to final demand being calculated, the capital-output ratio for the base year is updated to the forecast year.

$$FCOR_{k,t+1} = BCOR_i (\exp^{RCCOS_{k,t+1}}) \quad (40)$$

Where:

$FCOR_{k,t+1}$ = forecast year capital - output ratio for sector

$BCOR_k$ = base year capital - output ratio for sector

$RCCOS_{k,t+1}$ = rate of change in capital - output rate

$RCCOS_{k,t+1}$ applies in the forecast year for sector where $RCCOS$ equals $r_{k,t+1}$ in equation (36).

The capital-output ratio for the forecast year is multiplied by last year's output level to obtain the capital requirements needed for the forecast year. That is,

$$FD_{k,t+1} = (FCOR_{k,t+1})(XB_{k,t}) \quad (41)$$

Where:

$FD_{k,t+1}$ = capital requirements for industry k in year t+1

$FCOR_{k,t+1}$ = capital-output ratio for industry k in year t+1.

$XB_{k,t}$ = gross output for industry k last year

Output Forecast and Constraints on Capacity

The capital formation vector is summed with the PCE, government and export vectors to obtain regional final demand in the forecast year. Final demand is multiplied by the Leontief inverse matrix to obtain the direct and indirect impacts of changes in final demand on gross output in the region. That is,

$$X_{k,t+1} = (I-A)^{-1} (FDS_{k,t+1}) \quad (42)$$

Where:

$(I-A)^{-1}$ = the inverted inter-industry matrix

$FDS_{k,t+1}$ = the summed final demand sectors in year t+1

$X_{k,t+1}$ = gross output in year t+1

The gross output calculated above ($X_{k,t+1}$) is considered to be the optimal output necessary to meet the new final demand levels. In reality, the optimal output is rarely obtained because of production bottlenecks represent a form of demand - push inflation. In this algorithm, bottlenecks reflect the difference between optimal expansion and realized expansion in output. Implicit here is the condition that the required capital for expansion and replacement will be available. If this capital is not available, capacity utilization rises. The closer capacity utilization moves toward the practical capacity level the greater the potential constraint output. At this stage, the model does not incorporate the practical capacity levels which can be found in the Survey of Plant Capacity Bureau of the Census. It is assumed that 100 percent capacity is the maximum realized capacity level.

Initially, output changes are calculated. That is,

$$DO_{k,t+1} = (X_{k,t+1} - X_{k,t})/X_{k,t} \quad (43)$$

Where:

$DO_{k,t+1}$ = The change in output for industry k

$X_{k,t+1}$ = output for sector k for forecast year

$X_{k,t}$ = output for sector k last year

Next, an adjustment is applied to ($DO_{i,t+1}$) which reflect the direct impact on the capacity required due to changes in output. Hence,

$$DO_{k,t+1} = (DO_{k,t+1})^{0.93} \quad (44)$$

For example, if output rises by 5 percent ($DO_{k,t+1}$) then this requires a 6.2 percent increase in capacity utilization in order to meet the 5 percent growth rate. It is suggested here that changes in capacity utilization are not linearly related to changes in output because of the requirements of having some degree of slack in the production facilities relative to the input requirements to meet demand. Recall that equation (36) is used to calculate new capital requirements associated with replacement of existing capital. The equation implies that increased demand by the economy affects the physical plants of each industry uniquely, and the relative pressure to replace depreciated or worn out capital varies from industry to industry. Industries that have higher demand for their products also have higher new investment requirements. Expected new investment is required to meet increased demand for output as well as replacement of existing plant and equipment. If expected investment is achieved in the model, then production bottlenecks within the identified industry are minimized. Equation (45) expresses this function as follows:

$$OIR_{k,t+1} = (DO_{k,t+1} + DR_{k,t+1}) (Z)(e) \quad (45)$$

Where:

$OIR_{k,t+1}$ = new required investment coefficient

$DO_{k,t+1}$ = change in output from t to t+1

$DR_{k,t+1}$ = change in replacement due to changes in output

Z = a deflator based upon capital growth

e = the real interest rate

The variable (Z) is expressed by the following relationship:

$$Z = (IFD_{k,t+1} - IFD_k) / (IFD_{k,t+1} + 1.05) / (DO_{k,t+1} + 1) \quad (46)$$

The expected investment calculated for the forecast year is subtracted from the replacement and expansion requirements for the forecast. If expected investment equals required investment then the capacity utilization multiplier will be (1), and therefore capacity utilization will be the same as last year. This is expressed as

$$DCU_{k,t+1} = 1 + DOR_{k,t+1} + DRCR_{k,t+1} - OIR_{k,t+1} \quad (47)$$

Where:

$DCU_{k,t+1}$ = capacity utilization multiplier

$DOR_{k,t+1}$ = coefficient of output capacity

$DRCR_{k,t+1}$ = coefficient of replacement capital

$OIR_{k,t+1}$ = expected capital investment coefficient.

Capacity utilization for the purposes of the model differs somewhat from the census definition. Capacity utilization in this case only reflects the increased stress that occurs on plant and equipment due to either increased demand or increased replacement requirements. It is designed as a measure of the potential impact on the supply of goods that are demanded in the forecast year.

It assumes that as capacity utilization rises, the probability of production bottlenecks rise also affecting the capability of an industry to meet the expected demand. The capacity utilization factor for the forecast year is expressed as:

$$CFF_{k,t+1} = (CFB_k)(DCU_{k,t+1}) \quad (48)$$

Where:

$CFF_{k,t+1}$ = new capacity factor which is less than 1.0

CFB_k = base year capacity factor derived from census data

$DCU_{k,t+1}$ = capacity utilization multiplier for each industry

The difference between the forecast year capacity factor and the base year factor is the shortfall in the production goal of supplying goods to meet demand.

$$DCF_{k,t+1} = CFF_{k,t+1} - CFB_{k,t+1} \quad (49)$$

Where:

$DCF_{k,t+1}$ = change in capacity utilization from year t to t+1

$CFF_{k,t+1}$ = forecast year capacity utilization rate

$CFB_{k,t+1}$ = base year capacity utilization rate

Finally, the change in capacity utilization is transformed to obtain an elasticity measure of the potential output that will actually be supplied to meet demand. The demand is defined as the unconstrained output obtained from equation (37). The supplied output is expressed as:

$$AX_{k,t+1} = X_{k,t+1} (\cos \sqrt{DCF_{k,t+1}}) \quad (50)$$

Where:

$AX_{k,t+1}$ = output to be supplied

$X_{k,t+1}$ = output needed to meet this final demand

$\cos \sqrt{DCF_{k,t+1}}$ = coefficient of constrained production

The expression $(\cos \sqrt{DCF_{k,t+1}})$ is defined as an elasticity measure because it performs the function of estimating the percentage reduction in output due to the difference between the calculated utilization factor and the base year. For example, a 1 percent change in the capacity utilization factor results in a .04 percent decline in output in the sector and a 6 percent change in the utilization factor results in a 2.9 percent production gap between the supply and demand of an output. The purpose of the component is to obtain insight into the impact of interest rates on capital investment, and capacity utilization. Clearly this procedure is quite simplistic because it does not incorporate the impacts of tax laws which might encourage capital investment during periods of high real interest rates. On the other hand, tax advantages or disadvantages real interest rates influence decisions with respect to capital investments (which are

generally long-term investments), and play a major role in both the long and short-term economic capabilities of industries.

Energy Consumption in Manufacturing

The energy equations in the economic sub-routine are used to calculate energy consumption of electricity and all other fuels in the manufacturing for each forecast year. Energy consumption is a function of three variables, the price of energy, the growth in output, and the energy intensities (energy/unit of output) of each industry sector. Rising energy prices affect the forecast from energy consumption through price elasticities, as well as capital investment in the forecast year. Higher energy costs increase the probability of substituting existing plant and equipment for more efficient plant and equipment which affects the energy intensities of each industry.

Since prices are in current dollars, there is an adjustment deflates the impact of prices annually if prices remain constant. In addition to the adjustment to price, a negative feedback component affects energy intensities in each sector. That is, higher initial energy prices result in incentives to obtain more efficient plant and equipment to reduce energy consumption. However, as we move into the future in the forecast, increasing energy efficiencies will require higher and higher real energy prices because technological innovation may become increasingly difficult with respect to efficiency of energy input-output because of such conditions as entropy.

The first equation in the energy forecasting model is used to calculate the elasticity of demand for energy given a price of energy. That is,

$$CE_{k,t+1} = (1+EE_k)(FI_k) \quad (51)$$

Where:

$CE_{k,t+1}$ = elasticity of demand with respect to the energy prices

EE_k = price elasticities for each industry sector

FI_k = price of electricity and price of all other fuels

Next, the energy intensity factor for each industry in the forecast is calculated. This equation represents the short-term (one-year) impact of higher energy prices in the forecast year. That is,

$$CC_{k,t+1} = (CC_{k,t}) (CE_{k,t+1}) \quad (52)$$

Where:

$CC_{k,t+1}$ = energy intensity coefficient for industry k

$CC_{k,t}$ = last years intensity factor

$CE_{k,t+1}$ = elasticity of demand in forecast year

Finally, the energy consumption in the forecast year is expressed as:

$$ENERGY_{k,t+1} = (CC_{k,t+1})(AX_{k,t+1}) \quad (53)$$

Where:

$ENERGY_{k,t+1}$ = energy consumption in industry k

$CC_{k,t+1}$ = energy intensity in industry k

$AX_{k,t+1}$ = output by industry k in year t+1

Now, this year's energy prices affect energy consumption in the next forecast year (t + 2) by influencing capital replacement and the energy intensity factor for that year. The first step in this process is to calculate the average price elasticity with respect to electricity and all other fuels. That is,

$$CQ = (CE(1) + CE(2))/2.0 \quad (54)$$

Where:

CQ = average price elasticity in year t+1

$CE(1)$ = price elasticity of electricity in year t+1

$CE(2)$ = price elasticity for all other fuels in year t+1

The average price elasticity, usually expressed in the range of 0.9 - 1.0, is multiplied by the capacity utilization multiplier to obtain a factor which is used to estimates energy intensity in year t+2. Implicit in this analysis is the assumption that the higher the realized expansion and

replacement of capital equipment the greater the efficiency of the production process. In addition, this assumes that firms will replace existing capital equipment with more efficient capital equipment. The relationship is expressed as follows:

$$aDCU_{k,t+1} = (DCU_{k,t+1}) (CQ) \quad (55)$$

Where:

$aDCU_{k,t+1}$ = fuel price impact of capital investment

$DCU_{k,t+1}$ = capacity utilization multiplier

CQ = average energy price elasticity impact

A $DCU_{k,t+1}$ variable greater than 1 implies that the industry is not able to optimally replace and invest capital in the forecast year. The greater ($DCU_{k,t+1}$) the less is the impact of higher energy prices with respect to energy intensities in the next forecast year. Correspondingly, if the real price of energy declines, the smaller the impact on the demand for energy, and hence (since the efficiency factor is determined multiplicatively) the energy efficiency factor will be closer to 1. A factor of 1 implies no increase in efficiency.

Therefore,

$$aCC_{k,t+2} = (CC_{k,t+1})(aDCU_{k,t+1}) \quad (56)$$

Where:

$aCC_{k,t+2}$ = energy intensity factor by industry for year t+2

$CC_{k,t+1}$ = energy intensity factor by industry for year t+1

$aDCU_{k,t+1}$ = elasticity of fuel price on capital requirements.

Even though new capital plant and equipment increases the efficiency of energy use per unit of output, existing plant and equipment is losing efficiency with respect to energy consumption because of entropy and equipment aging. Therefore, a multiplier is introduced to weight the preliminary energy intensity factor increasing the factor relative to the decline in energy intensity. The multiplier implies that as the forecast moves into the future, energy conservation gains will become

increasingly difficult because of technological barriers. It does not imply an increase in the energy intensity factor, but only slows the rate of decrease. That is,

$$aaCC_k = aCC_k(\exp^{X(t+1-t_0)}) \quad (57)$$

Where:

$aaCC_k$ = energy intensity factor industry k for year $t+1$

aCC_k = energy intensity factor in industry k for year t

X = the growth in entropy over time by industry

t_0 = base year

The ($aaCC_k$) variable is therefore the energy intensity factor used initially to calculate fuel consumption in the next year subject to the price of energy in that year.

Personal Income and Government Transfer Forecast

The remaining elements in this years forecast and the data requirements for new years forecast are real personal income and government transfer payments. The personal income forecast consists of multiplying the income vector of the transaction matrix by the gross output to obtain expected income growth for the forecast year. Since the income vector is not part of the inverted industry transaction matrix, personal income is a direct percentage of total output by each sector. Therefore,

$$PI_{k,t+1} = (PIV_k)(aX_{k,t+1}) \quad (58)$$

Where:

$PI_{k,t+1}$ = personal real income by industry sector

PIV_k = personal income vector for each industry sector

$aX_{k,t+1}$ = actualized output for each sector in the forecast year

Finally, the model calculates the transfer payments for the next year that will influence personal consumption expenditures for the next

forecast year. Transfer payments are a function of the change in the unemployment rate in the forecast year over last year, the change in the over 65 population and the change in personal real income. The first two components positively affect (increase) transfers if the levels of both increase. Whereas, an increase in real personal income negatively affects (decreases) transfer payments because it implies the economy is growing.

The increase in transfer payments due to increases in unemployment is the result of the private sector not maintaining a level of growth equal to the growth in the labor force. Therefore, in the model, we recognize that the full effects of declines in the economy are moderated by government intervention into the economy with respect to transfers.

The government transfers equation is expressed as follows:

$$GTR_{t+1} = GTR_t(\exp^{E_o}) \quad (59)$$

Where:

GTR_{t+1} = transfers in the forecast year

GTR_t = transfers last year

$E_o = .2 * \ln(UNEMQ/UNEMP) + \ln(Pop66_{t+1}/Pop66_t) + \ln(PI_t/PI_{t+1})$

Input-Output Forecast Model

Input-Output analysis is a mathematical technique used to define the linkages that bind together the activities of industries in a complex feedback economy. Equation (42) presents the relationship necessary to obtain a gross output estimate given demand by consumers for goods and services. The input-output table used in this model is developed using IMPLAN Pro Version 2.0 and the most recently available database for California.

The basic data of an I/O matrix are a set of material (dollars) flows, X_{rc} to other industries for use in the production of their goods and Y to the final demands or final consumption sections of the economy. These are related by the equation,

$$\sum_c X_{rc} + Y_r = X_r \quad (60)$$

or in matrix notation

$$AX + Y = X$$

Which can be manipulated to yield

$$Y = X - AX = X(I-A) \quad (61)$$

or

$$(I-A)^{-1} Y = X$$

Where $(I-A)^{-1}$ is the inverse of $(I-A)$. The importance of equation (61) is that, given a final demand vector or bill-of goods (Y_r), the total gross output of the economy represented by the matrix of coefficient $(I-A)^{-1}$ can be computed. By use of matrix algebra, the procedure of manipulation in estimating output assumes a linear homogeneous relationships between output of an industry and the various industrial supplies and services the industry must purchase to produce an output. The model assumes that technology substitution because of changes in prices does not occur over-time. This is a major criticism of I/O modeling. It may be that the importance of substitution due to changes in relative prices may not be that significant, however, in production economics. Money inputs are highly complementary and even with wide variations in relative prices; the combination of inputs may only be slightly affected. Technological innovations reported in the literature lend the impression that the pace of technological advance is very rapid. Research in the area of technological substitution has not as of yet independently evaluated this assumption.

In the case of the I/O used in HENRY, the models accuracy with respect to estimating the precise trade flows between consuming, producing, importing and exporting industries is not as critical as if the model were used to analyze regional trade patterns. Since HENRY uses the transaction matrix to forecast gross output only due to changes in final demand, any error that might occur with respect to estimating the production coefficient in the I/O is minimized. That is, we assume that errors are randomly distributed above and below the actual production coefficient. If this assumption is correct, the sum result will minimize any error in each cell in the matrix. One critical problem that will be worked upon in the model update is the approximated change in the production trading patterns over time. Recognizing that substitution of inputs do take place due to price and technological

change, various techniques are under review to permit a forecast of the trade flow changes. This is particularly critical in forecasts greater than ten years.

Figure 3
Economic Forecasting Model

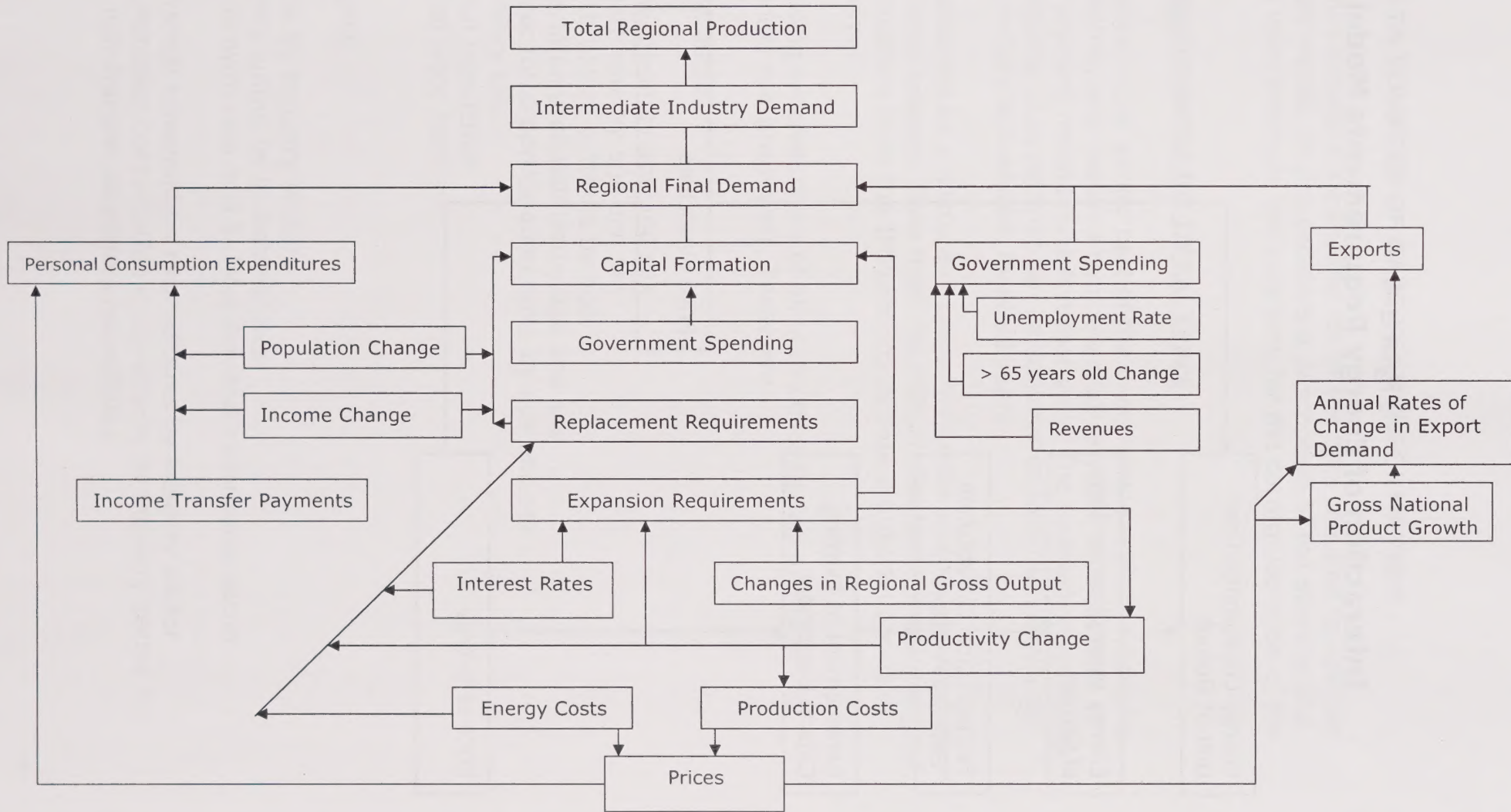
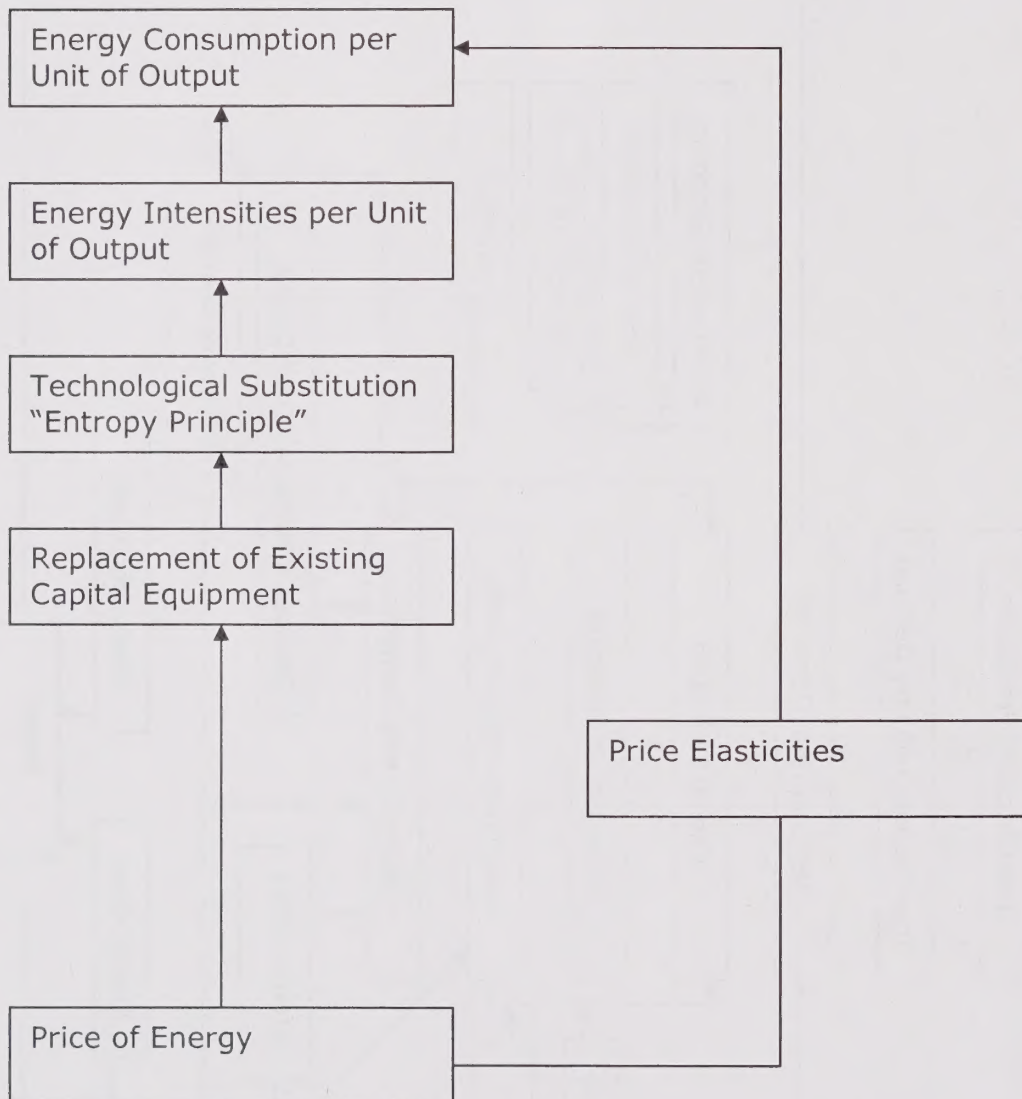


Figure 4
Interaction of Energy Requirements Model



IV. DATA SOURCES OF BASE YEAR INFORMATION

This section provides a complete list of the data required to operate the HENRY model. It also provides a description of the sources and methods used to create the data sets for the current iteration of the model.

Data Requirements for Initial Years

As explained in the earlier part of the document, the Henry model is semi-dynamic, and requires two consecutive years of input data in order to produce results for a forecast year. The forecast year results are a complete data set that can be substituted into the initial year data to produce subsequent forecast years.

Data is obtained as a mixture of primary sources and secondary data from national sources. Data from the IMPLAN California Database, and model equations from the IMPLAN Pro version 2.0 model are used extensively.

The following presents a list of all of the data requirements of the Henry model in a given year. These are:

A. Demographic

- Population by age and sex
- Death rate by age and sex
- Birth timing patterns by age
- Migration probabilities by age and sex
- Labor force participation rates by age and sex
- Fertility rate
- Total population
- Total labor force

B. Economic

- Jobs by industry sector
- Gross output by industry sector
 - Growth rate in U.S. final demand by industry sector
- Personal consumption expenditures by industry sector
 - Personal consumption expenditures by industry sector for non-transfer payments households

- Personal consumption expenditures by industry sector for transfer payments households

Government purchases by industry sector

Capital requirements for non-construction sectors

Capital formation for construction sectors

Exports by industry sector

U.S. final demand by industry sector

Annual rate of change in regional market share by industry sector

Output per worker by industry sector

Annual rate of change in output per worker by industry sector

Personal income elasticities by industry sector

Price elasticities by industry sector

Annual rate of change in government purchases by industry sector

Annual rate of change in the capital-output ratio by industry sector

The reciprocal of the average life of plant and equipment by industry sector

The maximum preferred level of operations of capacity by industry sector

Capital-output ratio by industry sector

Annual rate of change in replacement capital requirements by industry sector

Total jobs in $t-2$

Total jobs in $t-1$

Total jobs in t

Total personal consumption expenditures

Personal income per capita

Change in personal income per capita $t-1/t-2$

Change in personal income per capita $t/t-1$

Family size of migrating workers

Lower unemployment rate limit

Mid-point unemployment rate

Upper unemployment rate limit

Real interest rate

Historical growth rate of government receipts

Forecast growth rate of government receipts

C. Energy

Elasticity estimates for electricity and all other fuels by
manufacturing industry sector
KWH per dollar of output by manufacturing industry sector
Btus per dollar of output by manufacturing industry sector

Data Sources

A. Demographics

Population by age and sex information for the base year may be developed from many different sources. In California, the Population Research Unit in the Department of Finance produces age specific forecasts of population by age and sex by county. In many states, the Department of Health produces population cohort data. If possible, Census data provides the best population pyramid. In those areas where the state does not produce data or the base year is not consistent with a Census of population year, the user may use cohort survival method to forecast the population for the base year, using national or state trend data.

Death rates by age and sex are obtainable through the Department of Health by county. Which is true in most states. In our model, the data might also be obtained through the California Department of Finance, Population Research Unit.

Birth timing pattern by age is defined as the fraction of women in each cohort who may have children in any forecast year. It is derived by dividing the base year births by the base year female population which provides age-specific birth rates. Age specific birth rates divided by the sum of age specific birth rates and multiplied by one-thousand gives base year timing distribution.

Data sources are Census, Department of Health data and forecasts by state or regional agencies of cohorts by age and gender.

Migration probabilities by age and sex were derived from California Department of Finance data of the age and sex of migrants into each county. If data is not available from state agencies, one might construct the migration probabilities by age and sex from Census data updated to the base year. This distribution can be calculated by the following formula:

Let, M_i = the numbers of male or female net migrants i

M_j = the numbers of movers by cohort

Therefore,

$$PMIG_{ij} = M_{ij} / (\sum_{i=1}^2 \sum_{j=1}^{99} M_{ij})$$

Where: $\sum_{i=1}^2 \sum_{j=1}^{99} PMIG_{ij} \leq 1.0$

Labor force participation rates were estimated for the base year based upon data provided by the California Department of Employment Development. If data provided by state or regional governmental agencies are not available, Census data updated to the base year may be used.

Fertility rate is the number of children born per female in the base year. It is obtained by dividing the sum of age specific birth rates by 1000 females in the base year. In the San Francisco Bay Region, the period fertility rate in 2000 was 1.70 children per female.

Total population data is the sum of population cohorts by age and sex.

Total labor force data is the sum of total labor force by age and sex.

Jobholders are estimated as an annual average using definitions that are consistent with the U.S. Census. A job includes both full and part time employment. A single individual can hold more than one job.

B. Economic

Jobs by industry sector is developed by using Census information, County Business Patterns data and any data that might be available at the local level (i.e., State Employment Development Department).

Gross output by industry sector is obtained as a result from the input-output modeling. The U.S. Department of Commerce keeps U.S. estimates of Gross Output by industry. Regional estimates are made using the IMPLAN software program and data. Regional purchase coefficients identify the portion of any industry's inputs that are produced locally. The software estimates coefficients based on commodity flow data. Adjustments are made to output in order to insure consistency with estimates of other key variables.

Growth rates in the U.S. final demand by industry sector is obtained initially from the source: The Structure of the U.S. Economy 1980-1985, U.S. Department of Commerce. Thereafter, with initial data by industry sector a comparison of the actual growth from the national input-output table was. With these estimates, a final update of the growth rates for the base year were made by reviewing the most recent data available concerning output forecast and technology information.

Personal consumption expenditures by industry sector was estimated using the Benchmark IO study and Consumer expenditure survey at the national level. Personal consumption expenditures are distributed to the local level based on the number of households and the level of household income, stratified by income level.

Government purchases were limited to state and local government purchases and purchases associated with the post-office and maintenance of federal government administrative operations in the study area. The distribution of federal expenditures to the region is made using federal procurement data that gives federal purchases to the county level. State and local expenditures are derived directly or distributed based on employment ratios.

Capital requirements by industry sector were estimated by using the 1997 Census of manufacturing, wholesale and retail trade and services. Estimates for agriculture and mining were used by applying the ratio of capital requirements in the national input-output table to the gross outputs in the regional table.

Capital formation by construction sector was obtained by using several sources of information. Residential and non-residential construction data was obtained from building permits issued during the base year. Highway, road construction, public works and utilities data was obtained from records of construction activities by public agencies during the base year. Regional maintenance and repair data was estimated from regional total construction expenditures by using a ratio of maintenance and repair to total construction in the national input-output table.

Exports by industry sector were developed from previous input-output studies of the San Francisco Bay Region.

U.S. final demand by industry sector was obtained from the most recent national input-output table. Growth estimates are made using

forecast data from Jay M. Berman "Industry Output and Employment Projections to 2010", and Betty Wu, "The U.S. Economy to 2010", Monthly Labor Review, Nov. 2001, vol. 124, No.11. Finally "The Long Term Budget Outlook", Congressional Budget Office, October 2000.

Annual rate of change in regional market share by industry was calculated by developing data at the regional and national level on employment growth by industry sector.

The formula used to estimate the above was:

$$\left[\frac{Re_{k,t} - Re_{k,t-a}}{Re_{k,t-a}} \right] \left[\frac{Ne_{k,t} - Ne_{k,t-a}}{Ne_{k,t-a}} \right]$$

Where:

$Re_{k,t}$ = regional employment in sector k in year t.

$Re_{k,t-a}$ = regional employment in sector k in year t-a

$Ne_{k,t}$ = national employment in sector k in the base year

$Ne_{k,t-a}$ = national employment in sector k in the initial year

If output data is available by sector then that data in constant dollars should be used. Employment as such tends to distort the efficiency of the industry in a region relative to the same industry nationally because it does not consider fully productivity.

That is, an industry may be losing jobs relative to the nation in an industry, which would indicate a decline in regional market share. However, a review of output data might indicate that output growth was greater in the region than in the nation, and hence falling employment or stable employment would indicate rising output per worker.

Output per worker by industry is simply output by sector divided by workers in each industry sector.

Annual rate of change in output per worker by industry sector was estimated by reviewing annual percentage changes in productivity at the national level by industry sector. This data is available in

publications concerning current labor statistics in the Monthly Labor Review.

Personal income elasticities by industry sector were estimated by several sources. Clopper Almon, "A Perhaps Adequate Demand System" Presented at the Fourth Inforum World Conference Kamakura Japan, Sept. 20, 1996.

Price elasticities by industry sector were estimated using the review of elasticity literature included in Dynamic Revenue Analysis for California, P. Berk, E. Golon, B. Smith with J Barnhart and A. Dabalen, Summer 1996.

Annual rate of change in government purchases by sector was calculated by using the 1992 and 1997 national input-output tables. 1997 dollar values were inflated to 2000 values to obtain growth rates in constant terms. Each sector growth rates in spending for state and local government purchases only were calculated based upon recent historical information.

Annual rate of change in capital-output ratios by industry sector was initially calculated from data by Clopper Almon, et. al., "The U.S. Economy to 1975," pp. 54-69, and adjusted to the base year by reviewing capital-output ratios in recent national input-output tables. Finally, each rate was reviewed to accommodate perceptions about future capital requirements, technological innovations and economic conditions.

Capital-output ratios by sector were calculated from the 1997 Census of manufacturing. In order to assess the stability of these ratios, staff reviewed capital-output ratios for the 1992 Census of manufacturing which indicated that for most industries these ratios remained basically stable over the ten-year period.

Annual rate of change in replacement capital requirements by industry sector was originally calculated from information obtained in the publication, "The U.S. Economy to 1975," by Clopper Almon, et.al., pp. 54-69. Updated from national input-output tables and Belinda Bonds and Tim Aylor "Investment in New Structures and Equipment in 1992 by Using Industries" Survey of Current Business, December 1998.

The average life of plant and equipment by industry sector was calculated from data obtained in the publication, "1985: Interindustry Forecasts of the American Economy," pp. 74-75 by Clopper Almon, Jr.

The maximum preferred level of operations of capacity by industry sector data was initially obtained from data contained in the study, "Capacity Utilization: Concepts, Measurements and Recent Estimates," Brookings Papers on Economic Activity, 3: 1973 and adjusted to 1977 based upon capacity utilization data by major sector. More recent data is now available, however, which will be incorporated into the database. Annually, the Bureau of the Census produces a "Survey of Plant Capacity" on capacity levels by two-digit SIC level. This data provides estimates of the maximum level of capacity that each industry prefers not to exceed and the capacity level for the year. Current capacity utilization on a more aggregate basis is provided by "Industrial Production and Capacity Utilization" Federal Reserve Statistical Release G17.

The unemployment rate limit data is used to set a range in which levels of migration are affected depending upon the variance of the calculated unemployment and the unemployment rate limits.

Real interest rates are defined as the real cost of doing business when undertaking a transaction to borrow money. The real cost is determined by taking an average of Federal fund rates, prime commercial paper and the prime interest rate and multiplying that value by a fractional factor which reflects the tax write-off associated with the cost of doing business. The remainder is subtracted from the average inflation rate in the base year to determine the real rate. The real rate ranges from 0% - 4% in the model.

C. Energy

Energy elasticity measures were developed for electricity and all other fuels by using time series data from 1985-1994. Data is limited to manufacturing industries and is adjusted to be region specific.

KWH per dollar of output data is obtained by dividing base year electricity consumption by base year gross output.

Btus-per dollar of output was obtained by collapsing all other fuels into one category and estimating the Btu values, dividing this value by gross output by sector to obtain Btu's / dollar of output.

Data sources for the above are: "Changes in Energy Intensity in the Manufacturing Sector 1985-1994" Energy Information Administration; "Measuring Energy Efficiency in the United States Economy: A Beginning;" Energy Information Administration, October 1995; and

"Manufacturing Energy Consumption Survey 1994-1998" Energy
Information Administration.

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